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Training attention in physical education: effects on typically developing and DCD children

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Abstract

This study addresses the issue of whether (1) adding cognitive demands to the physical exercise tasks in physical education may promote the development of children's executive attention and (2) this 'enrichment' also matches the ability/skill level of children affected by Developmental Coordination Disorders (DCD). Results show a different efficacy of the two PE programs for promoting attention in typically developing and borderline/DCD children and highlight the need to find and continuously reset the degree of task complexity in PE to match the optimal challenge point of normal and special children populations.

Keywords: physical education, executive function, attention, DCD.

1. Introduction

There is increasing evidence of secular decremental trends in physical activity (PA) levels and fitness of children and adolescents (e.g., Tomkinson et al., 2003). Unfortunately, there is only scarce – and geographically limited – research effort as concerns the existence of secular trends of performance decline also in children's fundamental motor skills, such as jumping, throwing or catching, with a significant retardation and stagnation of the development of coordination subtending motor skill proficiency (Bös, 2003; Raczek, 2002) already starting at preschool age (Roth et al., 2010; Vandorpe et al., 2011). As a consequence, relatively scarce scientific attention has been devoted to the fact that PA guidelines for young people should also consider aspects other than fitness-related health particularly in the "skill hungry years" of childhood (Jacks, 1930, cited in Kirk, 2005), when strongest emphasis should be put on motor and cognitive development and skill learning.

Furthermore, relatively little research has examined how the qualitative characteristics of PA, particularly its coordinative and cognitive challenges, affect children's cognitive development (Best, 2010 for a review). The educational context may be a relevant one because schools are privileged settings where all children may be provided with quality PA experiences targeted to obtain not only physical fitness outcomes, but also cognitive outcomes that may support school learning and the development of goal-oriented behaviours. High-level cognitive

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functions, labelled executive functions, are clearly associated with school-related learning accomplishment (Diamond, 2007, Blair et al., 2008) and their efficiency is linked to children's habitual PA levels (e.g., Tomporowski, Lambourne, & Okumura, 2011). This suggests that PA is pertinent to the organization of learning supportive environments.

Unfortunately, although primary schools and school physical education (PE) represent an ecologically valid context in which quality PA experiences may be structured and provided to all children, the limited competence in PE of generalist teachers represents a barrier to this kind of intervention studies. The importance of specialist PE teachers in the early school years to promote lifelong PA has been advocated on a regular basis in several countries along more than a half century (Kirk, 2005). In Italy, despite of increasing initiatives of specialist-led primary PE interventions (e.g., the motor literacy program jointly promoted by the Ministry for Education and the Italian National Olympic Committee), we continue to lack a systematic presence of specialist PE teachers in early education and there still is a paucity of valid and reliable research on specialist-led intervention outcomes to inform policy development. Thus, we need more prospective field research joining measures of motor and cognitive development to evaluate the goodness of quality PA interventions. The results could help re-focus actual guidelines for PA prescription for children, grounding them not only on evidence of a dose-response relationship in the physiological domain, but also on evidence of a 'quality-response relationship' in the cognitive and coordinative domains (Pesce, in press).

The present study aimed at identifying relevant aspects of specialist-led PE for promoting the development of high-level cognitive functions. Specifically, we assessed whether an appropriate manipulation of the qualitative (coordinative and cognitive) parameters of PA prescription may induce cognitive enhancements.

While it has been also demonstrated that high-level cognition (i.e., executive functions) can be successfully trained in playful ways already at early age (Diamond & Lee, 2011), attempts to apply executive functions training in PE are still rare (Kubesch & Walk, 2009). Therefore, we verified the impact of PE on children's executive functions weather they were assigned to either a traditional, generalist-led PE program or to a specialist-led PE program with or without special focus on cognitively demanding physical activities ("gross-motor cognitive training"). Given the close interrelation between the development of the brain substrates responsible for motor coordination and that of executive function (Diamond, 2000), special attention was also devoted to evaluate what are the effects of the above mentioned quality PA interventions on cognitive functions of children affected by developmental coordination disorders (DCD) whose prevalence is relevant according to current European and American data (Tsiotra et al., 2006). Literature on exercise intervention outcomes in children with DCD is usually limited to outcomes in the motor domain (Miyahara, Yamagichi & Green, 2008), whereas studies on the impact of PA interventions on high-level cognitive functions of children with DCD are rare (Tsai, 2009).

2. Methods

Participants: Two hundred and eighty-six children aged 5-10 years from four schools of the Municipality of Rome (Italy) participated in the study. Within each school, four gender-balanced classes were selected according to teacher and class availability and assigned to different PE programmes. According to testing and normative data (Henderson & Sudgen, 1992), they were classified as typically developing, borderline or affected by Developmental Coordination Disorders (DCD) and it was controlled that the DCD children were uniformly distributed in the three groups (G-led: 14,2; S-led: 14,5; ccS-led: 14,4).

Tests and intervention: To assess both gross motor and fine motor coordination performance, a subset of locomotor tasks of *Test of Gross Motor Development-2* (TMGD-2, Ulrich, 2000) and *Movement Assessment Battery for Children* (M-ABC, Henderson & Sudgen, 1992, It. version 2000) were used. To assess attention performance relying on high-level cognitive function, the executive, a subset of attentional tasks (Expressive Attention, Number Detection and Receptive Attention) requiring to selectively focus on a particular stimulus and avoid responding to irrelevant stimuli from the *Cognitive Assessment System (CAS)* (Das, 2002) was administered to children. Outdoor play, PA levels and enjoyment were also evaluated to control for baseline differences potentially influencing the intervention outcomes by means of *Children's outdoor play assessment questionnaire* (Veitch et al., 2009*)*, *Physical*

Activity Questionnaire for Children (PAQ_C) (Kowalski et al., 2004), *Physical Activity Enjoyment Scale* (PACES, Kendzierski & De Carlo, 1991).

The intervention lasted six months with PE sessions once a week for one hour, the standard time in the Italian school curriculum. The experimental interventions were led by specialist teachers with a Sport Science degree. Three types of PA intervention were confronted: (i) generalist-led (G-led), (ii) specialist-led (S-led), (iii) cognitively challenging, specialist-led (ccS-led). The experimental intervention characterized by enhanced cognitive challenges was designed and structured to maximize the variability of practice by varying movement coordination and perceptual-motor timing demands. The intervention features were categorized as 'teacher's behavioural categories' according to the Observation System for Content Development-Physical Education (OSCD-PE, Rink, 2006) and the spectrum of 'teaching styles' by Mosston & Ashworth, (2002).

Statistical analysis: To verify whether children at different levels of motor development could have larger or smaller benefits from different types of PA interventions, a set of mixed model ANOVAs was performed on executive attention variables (Expressive Attention, Number Detection and Receptive Attention) with coordinative developmental level (normal, borderline, DCD), group (G-led, S-led, ccS-led), and testing time (pre- vs. post-intervention) as factors. In the case of significant effects, planned pairwise comparisons were performed where appropriate. Also, data were coded as a function of whether after the intervention the presence of coordinative developmental problem (borderline) or impairment (DCD) remained unchanged, or was ameliorated. This was verified comparing the percentage frequency of children who were classified as DCD before the intervention and as borderline after the intervention then ameliorated, shifting into the borderline group, and the percentage of children who were first identified as borderline, but at the end of the intervention were re-classified into the category of normally developing children.

3. Results

Among all indices of executive attention, only that of Receptive Attention showed a differential effect of the three types of intervention, indicated by a significant developmental coordination level x intervention group x testing time interaction ($F(2,249) = 3.13$, $p=.045$). As post-hoc tests demonstrated, typically developing children had a significant increment in Receptive Attention only if they participated in the specialist-led programme with additional cognitive demands (mean ± sd: pre 9.8 ± 3.7; post 13.0 ± 6.5). In contrast, children with coordinative problems (borderline) or impairment (DCD) showed highest improvements when involved in the specialist-led programme without cognitive enrichment (mean ± sd: pre 9.2 ± 3.6; post 12.0 ± 5.9).

Furthermore, there was a significant number of children who changed from DCD to borderline after the intervention period only in the group participating to the specialist-led programme with cognitive enrichment (46% vs. 0% and 1% for ccS-led, G-led, and S-led, respectively), whereas there were children who changed from borderline to normal in all intervention groups, but more pronouncedly in the ccS-led group (54% vs. 36% vs. 22% for ccS-led, G-led, and S-led, respectively).

4. Discussion

A relevant focus of this work was on whether qualitatively different types of PA interventions in school settings may differently impact executive functions of children affected by DCD and whether there is a most appropriate type of qualitative demands that may meet the need for an optimal challenge point for these children. This is a relevant issue, because there is a close interrelation between DCD and attention deficit disorders (ADHD) which depend on a poor functioning of the frontal lobe and, therefore, of the executive (Sergeant et al., 2006).

Results show a different efficacy of the two PE programs for promoting attention in typically developing and borderline/DCD children, promising evidence that can help identifying the optimal challenge point as a function of children's age and normal/abnormal status of their coordinative development. Our findings suggest that the preschool and primary school years may represent a 'sensible phase' in which attention can be optimally stimulated

by specialist-led quality PA experiences including targeted cognitive challenges. This is in line with evidence on the potential of action to affect cognitive development (Rakison & Woodward, 2008) especially during the sensitive periods in the development of brain structures subtending high-level cognitive function (Thomas & Johnson, 2008).

A general indication of effectiveness of the specialist-led PA with cognitive enrichment also for DCD children is the fact that it led to a relevant reduction of cases of children with motor problems (borderline cases) or impairment (DCD cases) that was negligible or lower in the group participating to the other types of PE intervention. However, the differential impact of specialist-led PE with or without a special focus on cognitive challenges suggest that the cognitive demands in PA must be finely tuned with children's developmental level of motor coordination to reap greatest gains in receptive attention, an aspect of attention that is particular relevant in educational settings. In fact, while typically developing children seem to benefit mostly from the cognitively enriched, specialist-led PE programme, borderline and DCD children seem to better profit from quality PA experiences led by specialist teachers, but without additional cognitive demands. Probably, the higher executive control needed by DCD children to cope with their difficulty in performing coordinated movements already represents a cognitive load that may lead to overload when they must cope with movement activities that additionally challenge their executive functions. This result strongly supports the concept of the importance to find the so-called 'optimal challenge point'.

References

Best, J.R. (2010) Effects of physical activity on children's executive function: contributions of experimental research on aerobic exercise. *Developmental Review, 30*, 331-351.

Blair C., Knipe H., Gamson D. Is there a role for executive functions in the development of mathematics ability? Mind Brain Educ., 2008;2:80-9.

Bös K., Motorische Leistungsfähigkeit von Kindern und Jugendlichen, in: Schmidt W., Harman-Tes I., Brettschneider W. D. (Eds.), Erster Deutscher Kinder- und Jugend-Sportbericht, Schorndorf, Hofmann, 2003, 85-107.

Diamond, A. (2000) Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex. *Child Dev*.71:44-56.

Diamond A., Barnett W.S., Thomas J., Munro S.(2007) Preschool program improves executive control. Science;318:1387-8.

Diamond, A., & Lee, K. (2011) Interventions shown to aid executive function development in children 4 to 12 years old. *Science, 333,* 954-969.

Kirk, D. Physical education, youth sport and lifelong participation: the importance of early learning experiences. Eur Phys Educ Rev, 2005;11:239-55.

Kubesch, S. &Walk, L. (2009) Köperliches und kognitives Training exekutiver Funktionen in Kindergarten und Schule.Sportswissenschaft,39, 309-317.

Miyahara M., Yamagichi M., Green C. A review of 326 children with developmental and physical disabilities, consecutively taight at the movement development clinic: prevalence and intervention outcomes of children with DCD. J Dev Phys Disabilities, 2008;20:353-63.

Pesce, C. (in press). Shifting the focus from quantitative to qualitative exercise characteristics in exercise and cognition research. *Journal of Sport and Exercise Psychology.*

Raczek, J. (2002). Entwicklungsveraenderungen der motorischen Leistungsfaehigkeit der Schuljugend in drei Jahrzehnten (1965-1995) [Changes in motor performance development of school children during three decades (1965-19959]. Sportwissenschaft, 2002;32:201-16.

Rakison, D. H., & Woodward, A. L.(2008). New perspectives on the effects of action on perceptual and cognitive development. Developmental Psychology, 44, 1209–1213.

Roth, K. Ruf, K., Obinger, M., Mauer, S. , Ahnert, J., Schneider, W, Graf, C, Hebestreit, H. (2010) Is there a secular decline in motor skills in preschool children? *Scand J Med Sci Sports* 20: 670–678.

Sergeant, J. A., Piek, J. P., Oosterlaan, J.(2006) ADHD and DCD: A relationship in need of research, *Human Movement Science,* 25, 76–89

Thomas, M. S. C. & Johnson, M. H. (2008). New advances in understanding sensitive periods in brain development. *Current Directions in Psycholoogical Science, 17,* 1-5.

Tomkinson G.R., Leger L.A., Olds T.S., Carzola G. (2003) Secular trend in the performance of children and adolescent (1980-2000): an analysis of 55 studies of the 20m shuttle run test in 11 countries. *Sport Medicine*, 33, 285-300.

Tomporowski, P. D., Lambourne, K., Okumura, M. S. (2011) Physical activity interventions and children's mental function: An introduction and overview. *Preventive Medicine, 52,* 3-9. doi: 10.1016j.ypmed.2011.01.028

Tsai, C.L.(2009) The effectiveness of exercise intervention on inhibitory control in children with developmental coordination disorder: using a visuospatila attention paradigma as a model. Res Dev Disabil. 30: 1268-80.

Tsiotra, G.D., Flouris, A.D., Koutedakis, Y., Faught, B.E., Nevill, A.M., Lane, A.M., and Skenteris, N. (2006) A Comparison of Developmental Coordination Disorder Prevalence Rates in Canadian and Greek *Children. Journal of Adolescent Health.* 39, 125–127.

Vandorpe, B., Vandendriessche, J.,Lefevre, J., Pion, J., Vaeyens, R. Matthys, S., Philippaerts, R., Lenoir, M. (2011) The Körperkoordinations Test für Kinder: reference values and suitability for 6–12-year-old children in Flanders *Scand J Med Sci Sports*. 21: 378–388.